PMT Mechanical Characterization

NUWC testing and analysis to determine chain-reaction PMT implosion mechanism

BNL Small Chamber Tests & Super K Forensics

Experience from Japan's Super-Kamiokande experiment shows that, these PMTs can fail under hydrostatic pressure and shock wave produced by breakage of single PMT under pressure can produce a shockwave which can destroy neighboring PMTs. This is a high risk to the experiment in both cost and schedule

- BNL small chamber tests yielded pressure wave data, however the small volume affected the results
- Super K accident forensics investigation did not determine the direct hydraulic mechanism for the chain reaction

Some numbers SK simulation

20 inch tube

Pulse amplitude at 50 cm simulated to be 13.6 MPA

width >0.05 ms

Time of pulse 10.8 ms

Velocity of water at 50 cm

5.3 m/sec

2．解析結果

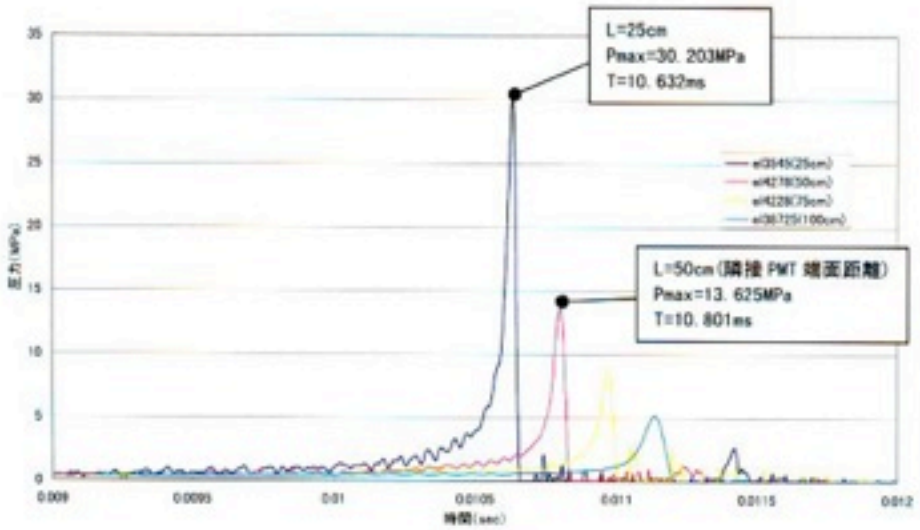


図-3　圧力時刻歴

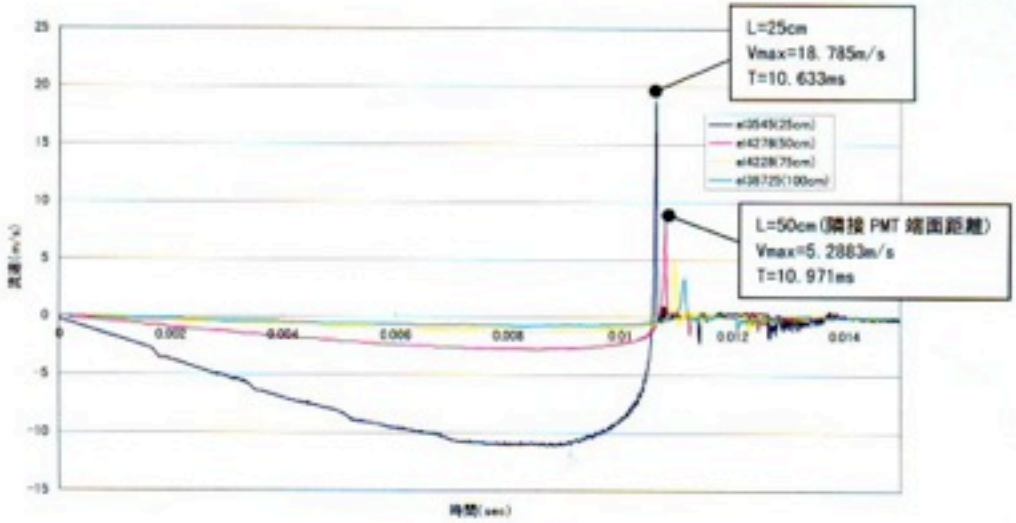
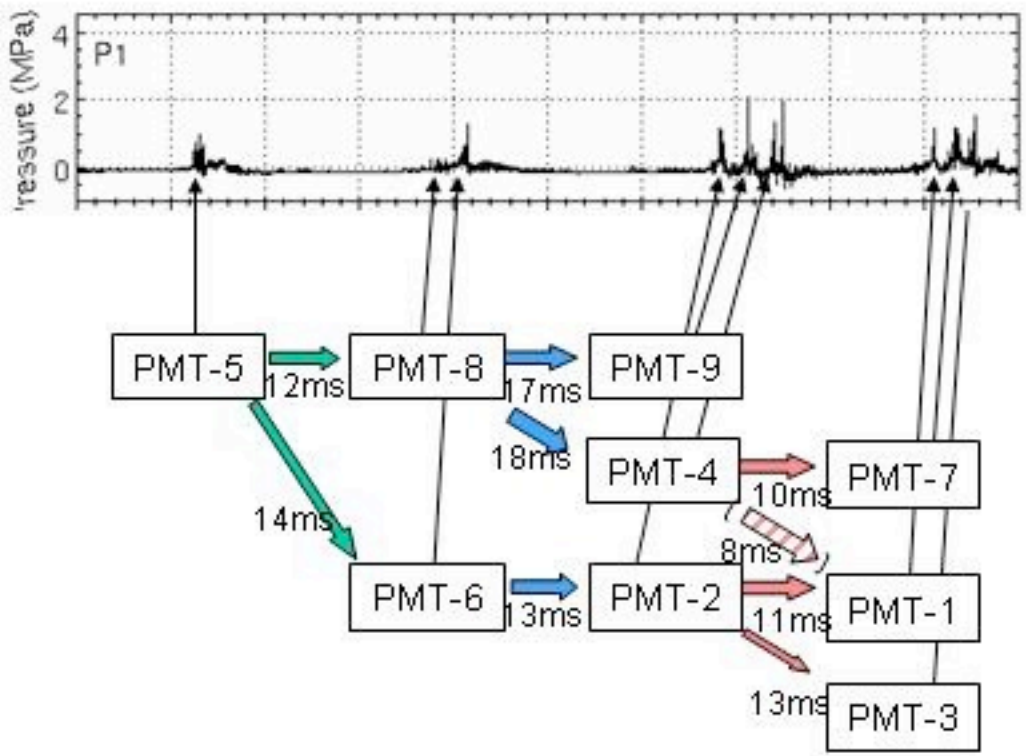
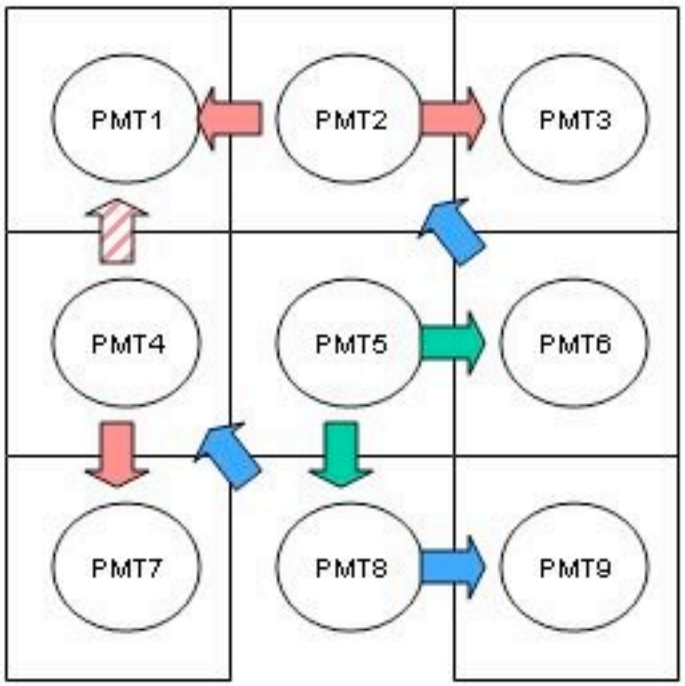


図-4　流速時刻歴

Implosion data

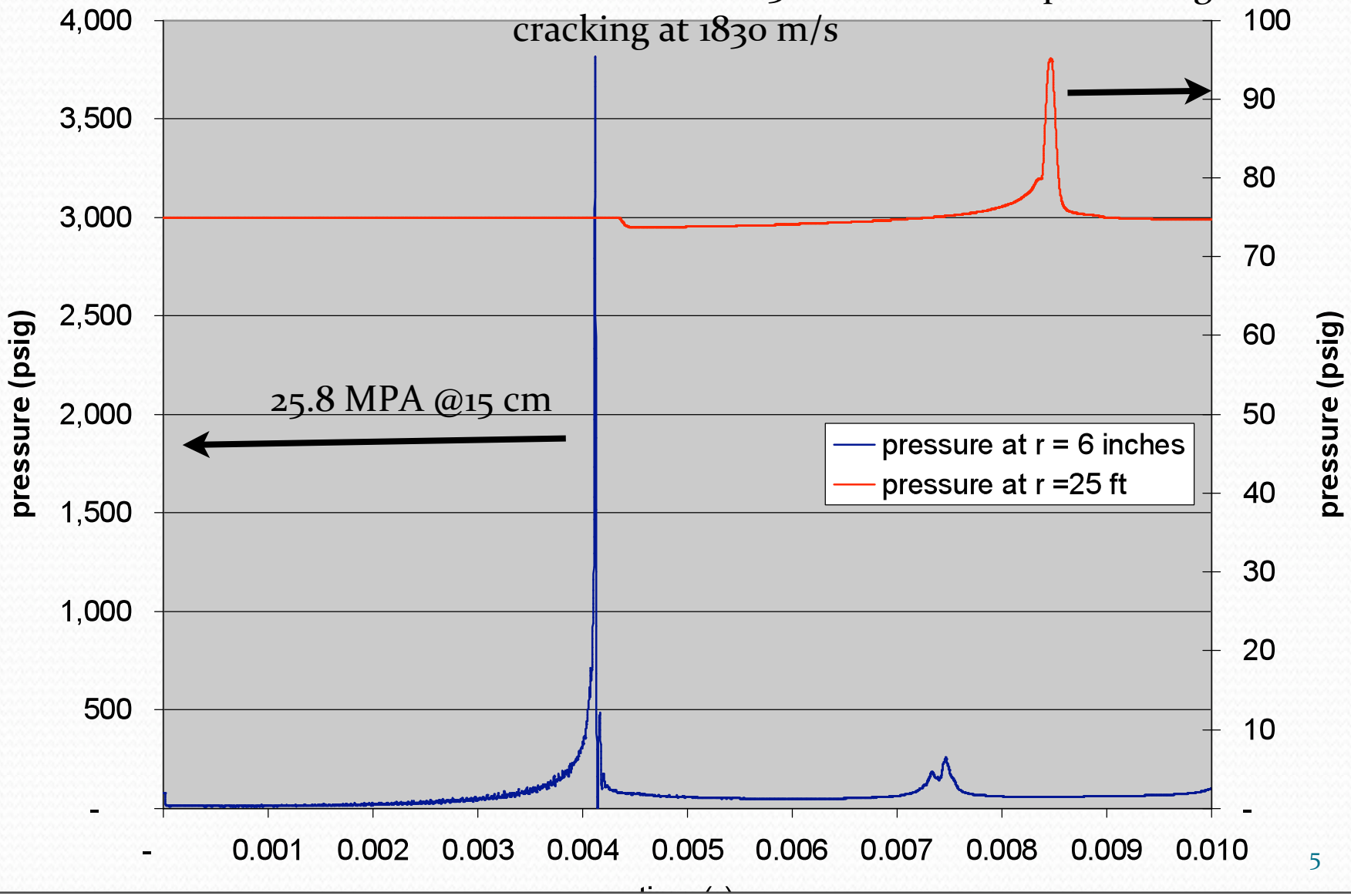




Observed pressure pulse at 0.45m from tube center is about 5.6 Mpa.
Idealized simulation predicts about 13 Mpa.

Prediction for 10 inch tube from ST

Pressure ~ 1/r (not 1/r^2 !)
=> at 50 cm prediction is 7.7 MPA peak
width ~ 0.01-0.03 ms with assumptions of glass cracking at 1830 m/s



Pressure wave or implosion energy

- It is yet to be determined whether the PMT implosion chain reaction is due to the pressure wave or the implosion energy (integration of the pressure vs. time curve).

- Preliminary simulation results, to date, indicate not a significant variation of the peak pressure with the size of the glass sphere but there must be significant variation in the implosion energy.

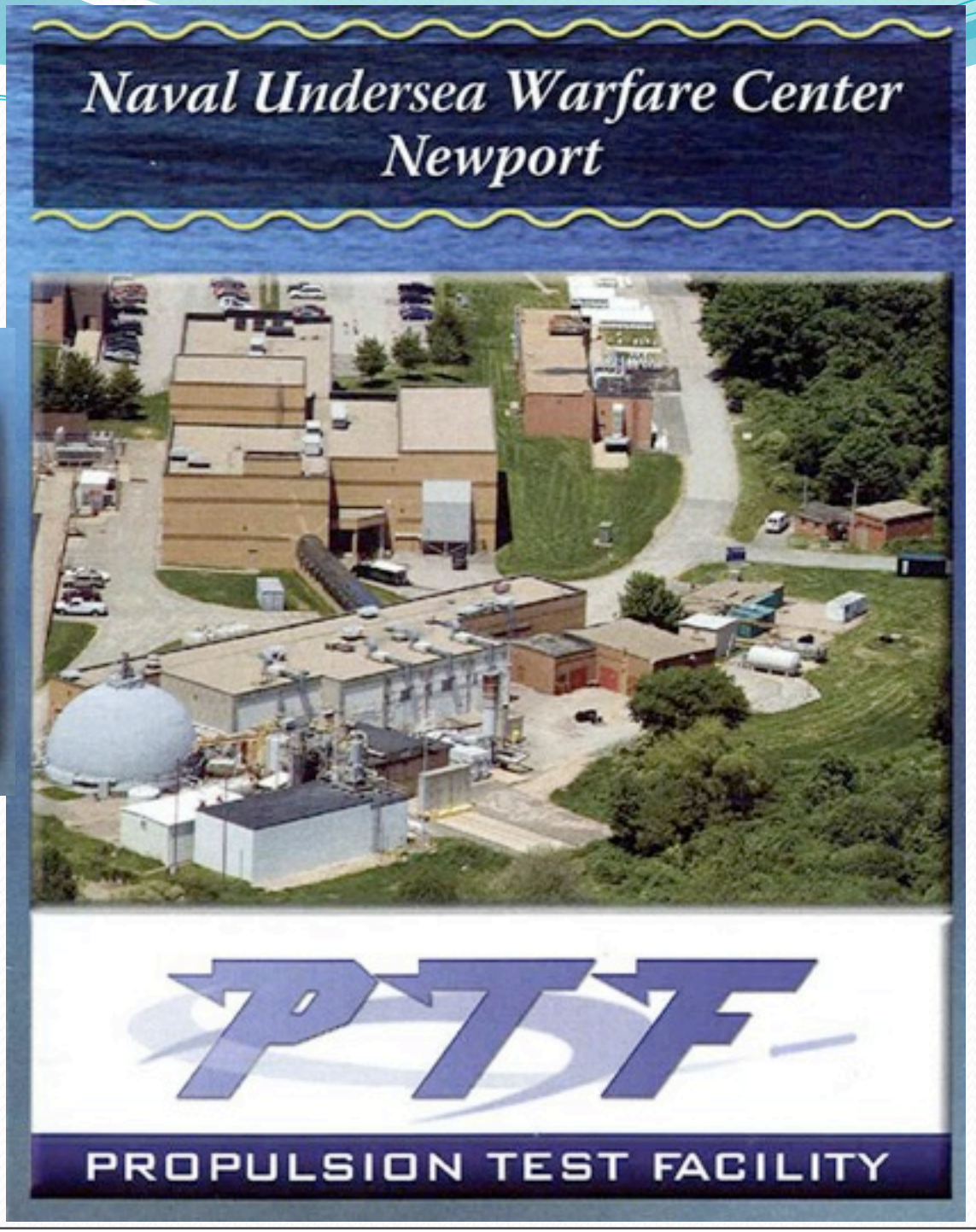
- Key issue: Does a neighboring tube break because of the peak pressure or the total energy imparted to it by the width of the pulse ?

- How do various parameters contribute to the failure: glass thickness, the position of the fixture, and coupling between the failed tube and the neighbor.

Mechanism of Implosion Chain Reaction

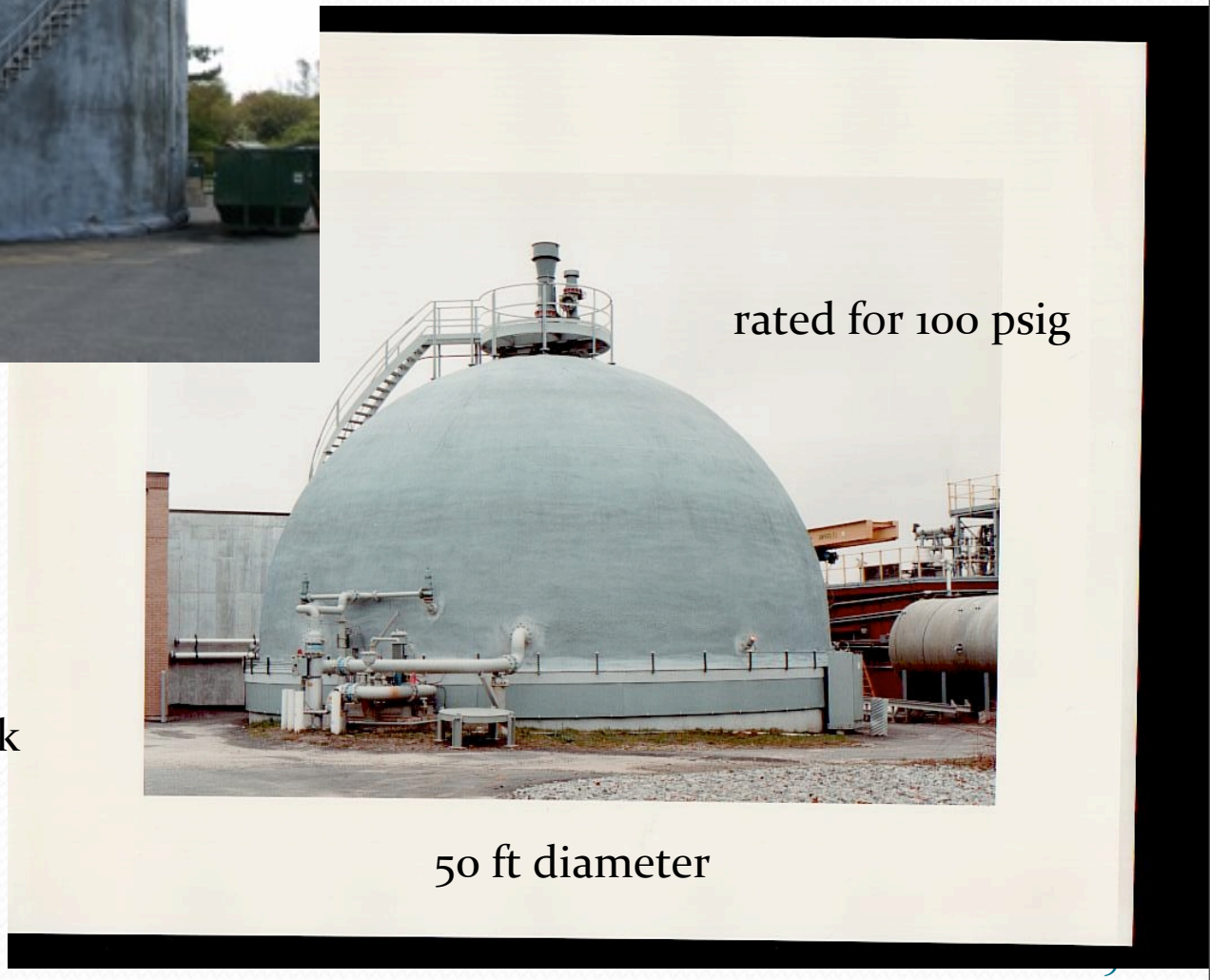
- First testing to accomplish “proof of test” capability and collect pressure wave and implosion energy data
- Full regime of testing will assist in design and development of all features surrounding PMT to abate the implosion chain risk
- We have found a facility for performing these tests.

The facility



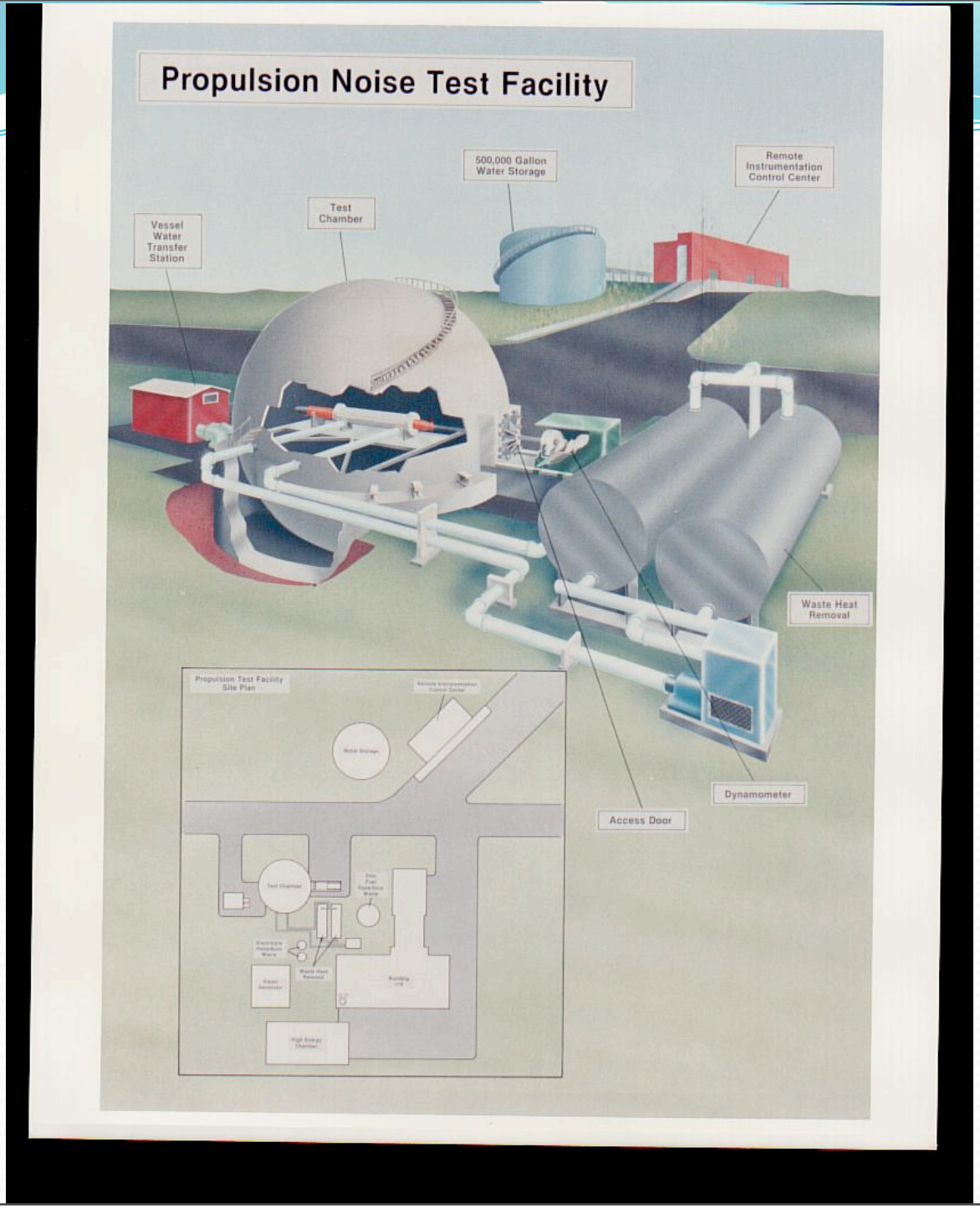
Storage tank

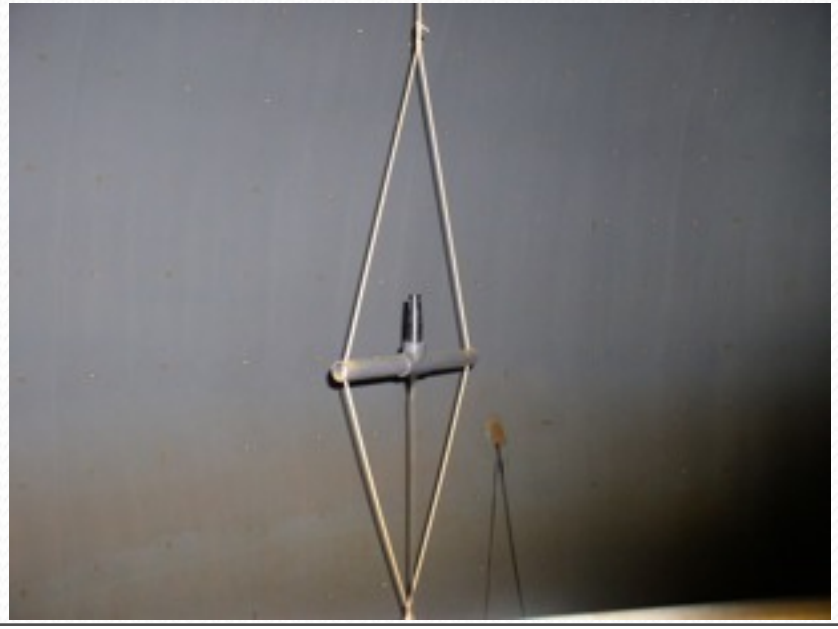
Pressure tank



rated for 100 psig

50 ft diameter


Propulsion Noise Test Facility
500,000 Gallon Water Storage
Remote Instrumentation Control Center
Test Chamber
Vessel Water Transfer Station
Waste Heat Removal
Dynamometer
Access Door
Propulsion Test Facility Site Plan



Clean facility
Good safety infrastructure
Knowledgeable staff
Full instrumentation and data acquisition
Cost of recommissioning and operation is being worked on.